Installation & User Manual

Alternator (Adjustable) Voltage Regulator – ZM5

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Why Do I Need A New Regulator?

Here's the dilemma. To charge your battery efficiently, you need a relatively high charging voltage (±14.7 V).

But if you stay at that voltage permanently, you will overcharge and damage the battery.

Conversely, if you use a lower charging voltage (<14V) you will prolong the battery life but will take a long time to reach full charge – in some cases, you might never actually reach full charge!

The solution is an adjustable, multi-stage voltage regulator for your alternator.

The ZM5 allows you to configure the optimal charging voltage for **your** specific battery, and after a set time will automatically switch to a lower 'healthier' voltage. The best of both worlds!

Typically, with automotive regulators, the battery acid does not get enough charge and this leads to acid stratification, which is where the water separates to the top and the acid settles on the bottom and in a 'pure' acid form will attack the battery plates leading to premature battery failure.

The charge voltage is probably the single most important factor in charging, as all other factors are related to it.

Signs that you could do with a new alternator voltage regulator include:

- Your battery is not charging to full capacity.
- Your battery is charging too slowly, and you're wasting fuel running an engine.
- Your battery suffers from sulfation.
- Your battery suffers acid stratification/damaged plates.
- You're technically minded and want better control over the charging behaviour.

Features

- An easily adjustable voltage setting to accommodate different battery types.
- Suitable for 12 and 24-volt system voltages (order desired voltage)
- Will regulate any N-type or P-type alternator (ensure you purchase the correct model based on your needs).
- A soft start to ease the sudden inrush of current.
- Any type of alternator can be run by this regulator, reduces run time, saves fuel, reduces noise and emissions.
- ABSORPTION and FLOAT stages, indicated by LEDs to show state.
- Can run two alternators with one ZM5, up to 25-amp **field** current.
- Overvoltage protection as well as reverse polarity.
- Size: 155mm long x 58mm high x 66mm wide.
- 24-month warranty, we will repair or replace free of charge. This warranty does not include damage resulting from incorrect installation, accident, misuse, or neglect. The warranty is void if the cover is removed or if the unit is tampered with.
- Designed, built, and supported in New Zealand.
- Circuit boards are treated with Conformal coating material to protect against moisture, dust, chemicals.
- See ZM5 operation and set up video on at "YouTube", search "ZM5 Smart Regulator"

Alternator Size

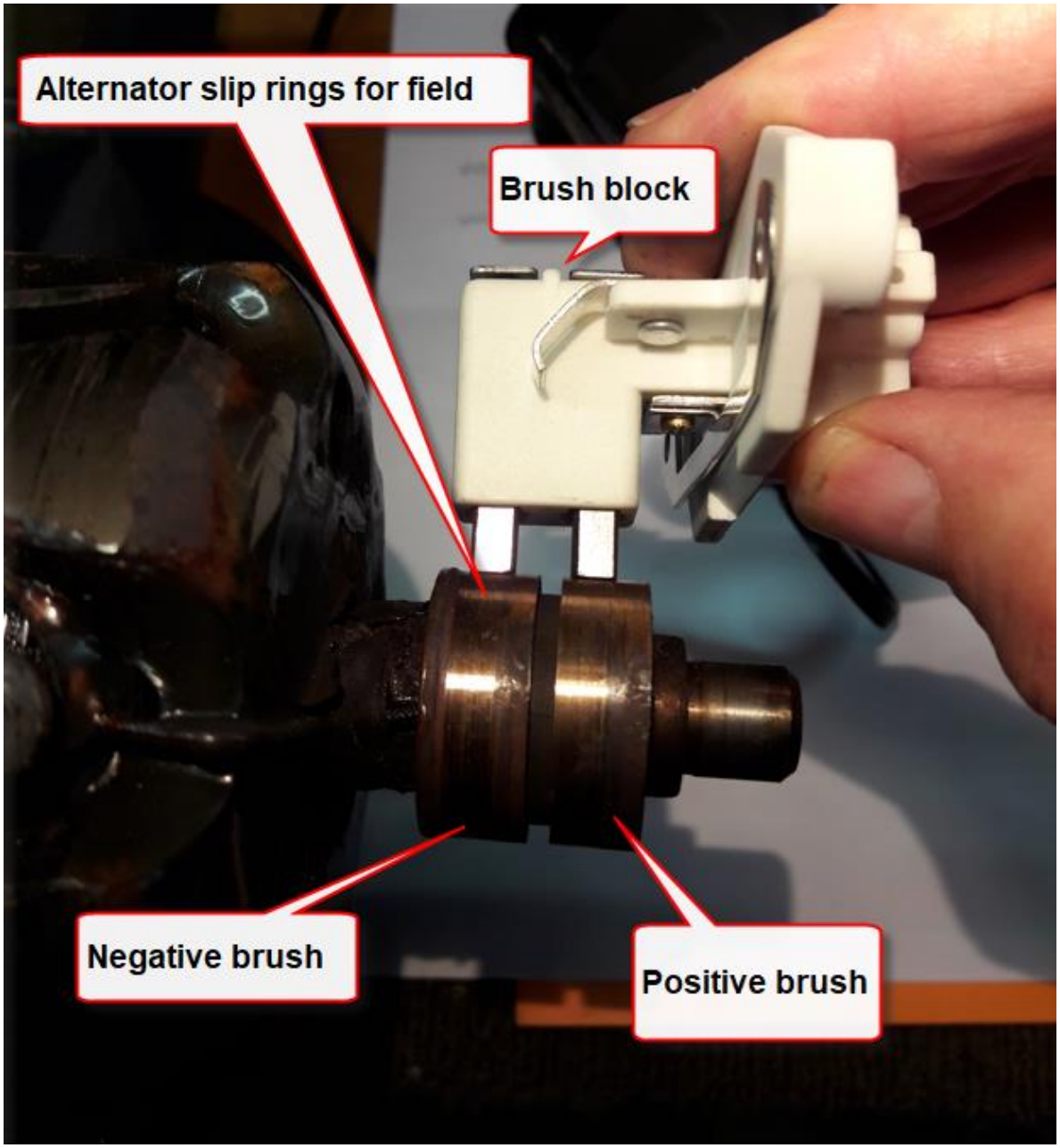
I always recommend a Bosch 80- 120 amp alternator, which is about the highest rating without going into high priced alternators.

No matter how good any smart regulator is, if the alternator is not spinning fast enough then you will not get a good charge current into your battery bank.

You need to calculate what your lowest cruising rpm is and arrange your pulley size to ensure your alternator is producing the best possible output, absolute minimum is 2500 alternator rpm.

Remember, for every 25 amps you will draw 1hp power of engine energy.

The following photo shows alternator brush orientation



Alternator Terminal Designations

We have listed the common alternator connection terminology for identification between different brands.

Make	Output	Negative	Field	Auxiliary	Tachometer
Bosch	B+	D -	Df	D+	W
Ingram	B+	B -	F	IND AL	W
Lucas	BAT	E	F	L	
Paris-Rhone	+	-	Df	61	W
Sev Marchal	B+	D -	Df	61	
Motorola	BAT	-	F	AUX	AC
CAV	D+	D -	F	IND	
AC Delco	Bat	GND	F		
Valeo	B+	D -		D+	W
Mitsubishi	B+	E	F	L	
Nippon Denso	B+	B	F	L	
Prestolite	POS+	GND	F	IND LT	AC
Silver Bullet	+	-	F		R

Alternator Test

We have had our units sent back as faulty; however, they test OK on our rig so a test you can do of your alternator is as follows:

- Using a digital volt meter, set to AC volts
- Measure between earth and alternator output terminal
- Voltage should be below 0.5v AC
- If any greater than 0.5vAC your alternator diodes are at fault and need to be rectified as they will damage delicate electronics on board, including the ZM5

Alternator Modification

There is no performance difference or advantage it is more an alternator manufacturer's choice.

Some alternators are best suited to the P-type but the majority are N-type.

The objective is to have the ZM5 N control the negative side of the brush block

The ZM5 N is a negative brush control system, this means that the positive brush requires power at all times and the theory is we control the negative brush which controls the output of the alternator as per the setting on the ZM5. The switching mode is indicated on a decal on the bottom of the unit. ***The unit cannot be used for P switching.***

The objective is to have the ZM5 P control the positive side of the brush block

The ZM5 P is a positive brush control system, this means that the positive brush is the field control and the negative brush is earthed
The switching mode is indicated on a decal on the bottom of the unit. ***The unit cannot be used for N switching.***

Modification of your existing alternator to accept an external regulator is a requirement and can be done by yourself or a reputable auto electrical shop. Depending on your alternator type, an external brush block is available from us or most auto electrical shops.

We also offer a service to modify your alternator.

We have available on the download section of our website instructions for different alternator conversions to accept an external regulator.

ZM5 Specifications

Voltage	12- volt or 24-volt versions are available
Polarity types	"N" or "P" switching versions are available
Charging stages	Bulk – Absorption - Float
Adjustable ratio Absorption to Float	Yes, adjustable by user (0 to 2 volts)
The factory setting for ratio	(12v) 0.6 volt - (24v) 1.2 volts
Approximate time at the Absorption rate	100 - 120 minutes
Absorption Indicator	Yellow LED
Float Indicator	Green LED
Alternator range	0-350-amp alternator
Maximum Field current	25 amps (most alternators are 3-5 amps)
12-volt version voltage adjustment range	12 to 15.5 volts
The factory setting for voltage regulation	(12v) 14.7 volts - (24v) 29.4 volts
24-volt version voltage adjustment range	24 to 32 volts
Reverse polarity protection	Yes
Overvoltage protection	Yes, adjustable by the user
The factory setting for overvoltage protection	(12v) 15.5 volts - (24v) 31 volts
Overvoltage/overtemperature protection	Shuts off FIELD control
Overvoltage/overtemperature Indicator	Red Flashing LED and buzzer (supplied)
Unit size	155mm long x 58mm high x 66mm wide.
Weight	150 grams
Cooling (24 volts only)	40mm fan, Cuts in at 38 degrees C
Fuses	Ignition and Field recommend min 5 amp
Fuses	Battery sense recommended min 1 amp

How the ZM5 works

Broadly, the ZM5 regulator consists of a timer block, voltage comparison logic, and a MOSFET output stage.

The timer block is responsible for overseeing the transition between the absorption and float stages, and is factory set from 100 - 120 minutes, combined with a relationship of battery voltage.

The voltage comparison logic continuously monitors the battery voltage and compares it to the voltage level you have selected with the adjustment control. The analog signal is modulated by an oscillator to feed the pulse frequency modulation signal for regulation whereby the MOSFET is turned on and off based on the output voltage as it changes, sensed by the oscillator.

Improved JFET-input operational integrated circuit (IC) has a lower Input Bias Current and high slew rates providing better overall performance.

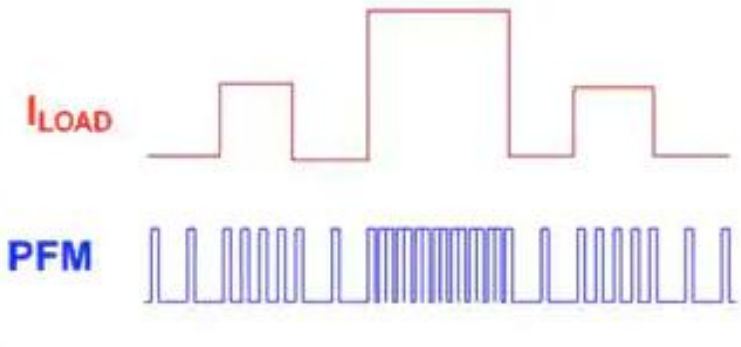
Once the voltage level has been raised back to your setting, the field current is disengaged. Hysteresis is built into the comparison logic to ensure the feedback loop remains stable.

A slight amount of current is held to ensure that the ignition light does not come on.

The unit design has an overvoltage function that disables the FIELD circuit in the event of an internal fault.

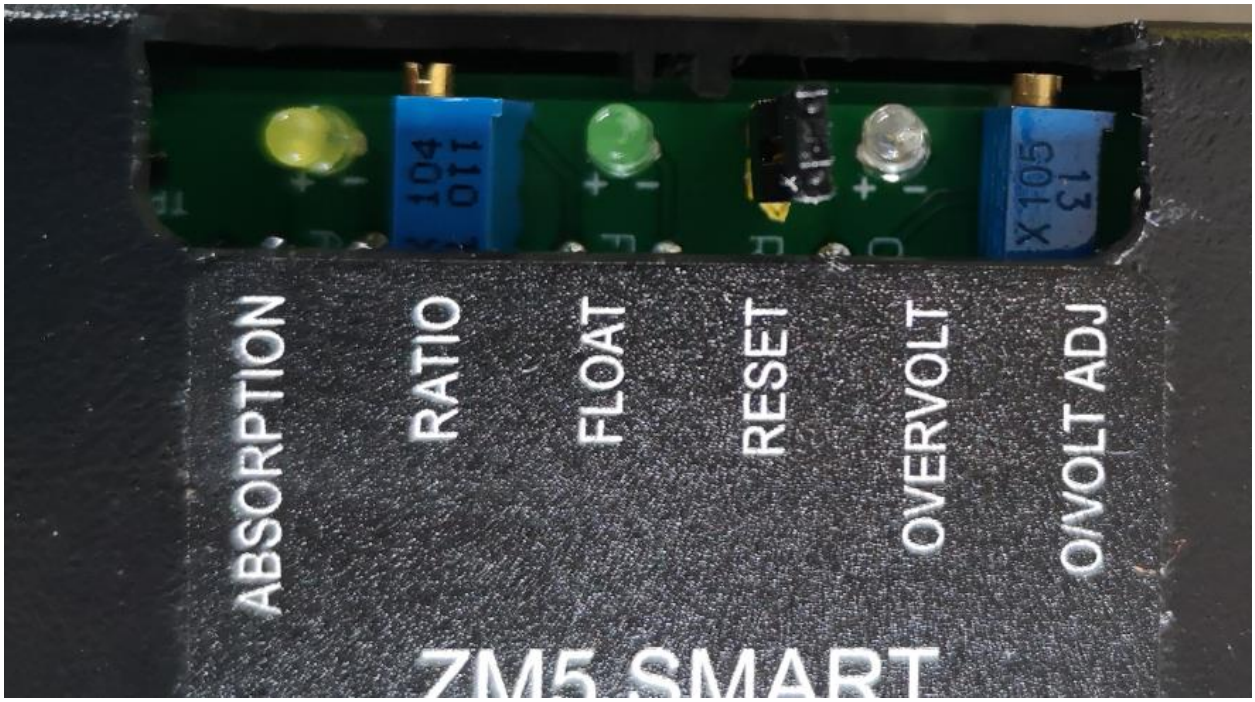
Control of reverse polarity is also built into the new design.

Any type of alternator can be run by this regulator, providing **field** current draw does not exceed 25 amps continuous or 30 amps intermittently.



Graph showing pulse frequency modulation versus load.

ZM5 Overview of controls



ABSORPTION – YELLOW Absorption LED

RATIO – Adjusting voltage between Absorption and float, Clockwise for increase, counterclockwise to decrease, see adjustment instructions.

FLOAT – GREEN Float LED

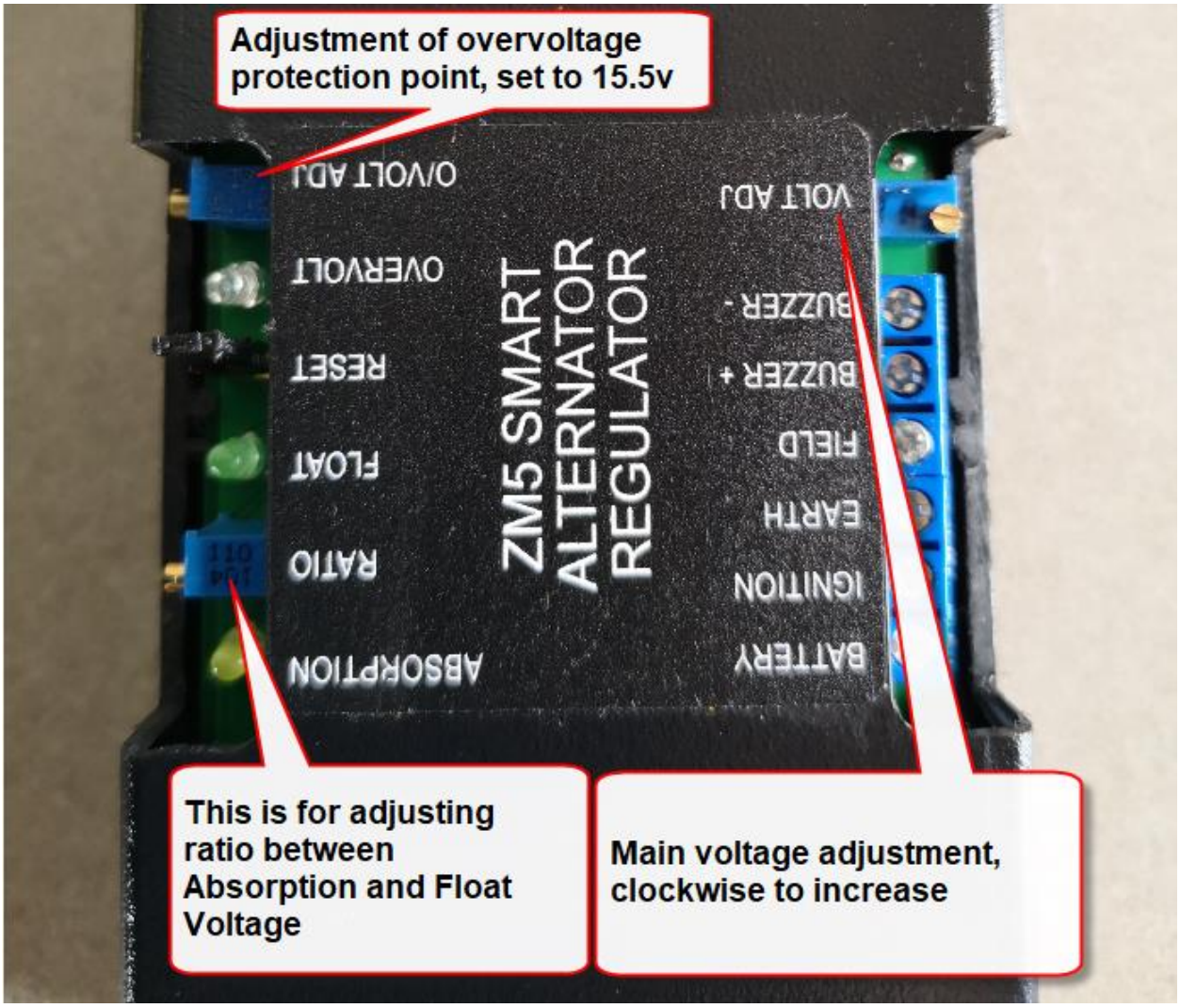
RESET – Voltage overvoltage/overtemperature reset jumper, with jumper removed, the system will detect but not disable the field circuit.

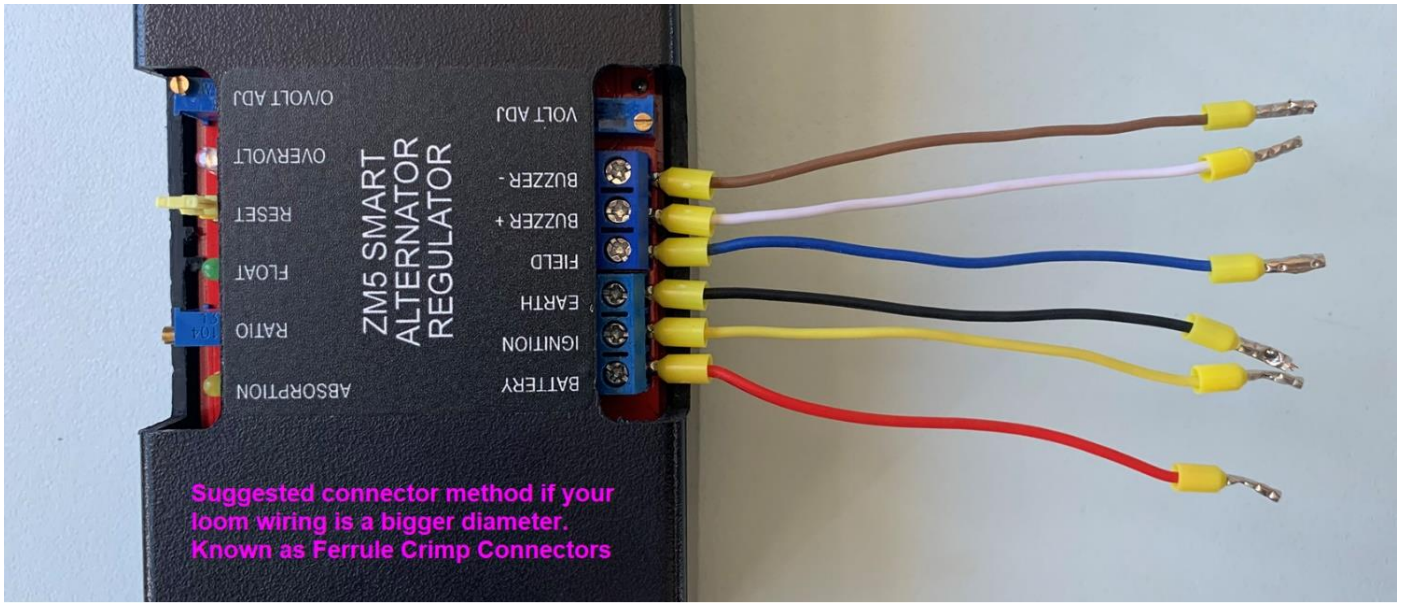
OVERVOLTAGE – RED Flashing LED for overvoltage/overtemperature situation, plus buzzer will sound (if fitted)

O/VOLT ADJ – Overvoltage adjustment, Clockwise for increase, counterclockwise to decrease. see instructions on the following pages

FAN – (only on 24-volt versions) The cooling fan is for the output stage MOSFET.

ZM5 Overview of controls



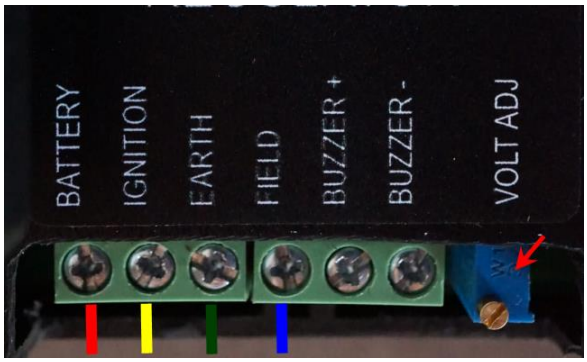


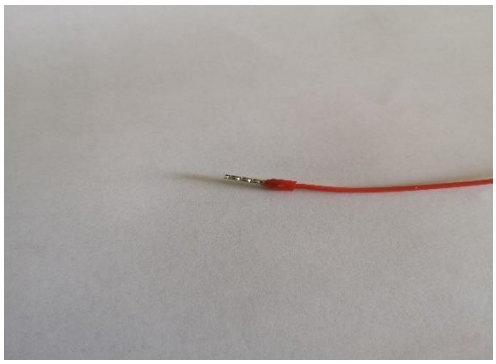
Installation

Mount the unit preferably remotely from the engine bay to ensure a clean dry, cool environment. Connect **NO** bigger than 14 gauge (2.5mm) (7.5amp) tinned wires to the following terminals.

A maximum of 4 metre FIELD wire distance from the alternator to ZM5 due to inductive switching of field, or else voltage fluctuations will occur.

Note: DO NOT overtighten screws in the terminal block, the thread will strip if over-torqued.





We suggest a ferrule crimp connection (Jaycar PT4433)

VOLT ADJ – the main adjustment for desired set voltage, 1 turn equals 0.12 volts. Clockwise to increase, counterclockwise to decrease.
BATTERY: Connect this terminal directly to the positive side of the battery. If you have two batteries i.e.: a start and house, suggest you connect it to the house battery, this will prevent any spikes from high drain current items like starters, etc. Suggest you use a red wire for this terminal, or mark the wire clearly. You should connect this wire with an inline fuse (1 amp) **Do not connect via any switch.**

IGNITION: Connect this terminal to the ignition switch. To avoid confusion a suggested colour is Yellow or mark the wire clearly. You should connect this wire with an inline fuse (5 amp) located close to the ignition switch. ***Do not connect the IGN to the D+ terminal of the alternator.*** Make sure that the ignition feed is off the same battery as the charging circuit, the reason is the battery overvoltage detection is a combination of BATT and IGN. voltages in the logic circuit. This should only be a problem with a separate starter battery alternator.

EARTH: Connect this terminal directly to a good negative supply bus bar. If you are unsure place, it directly on the negative post of the battery, suggest you use a black wire for this terminal, or mark the wire clearly.

FIELD: This unit controls the field side of the brush block. Connect this wire directly to the alternator field terminal. You should connect this wire with an inline fuse (5amp).

BUZZER + and -: If using the supplied buzzer/ light unit then the polarity is not critical. Maximum current draw 3 amps for any device connected. It is not critical to fit the buzzer as there is an onboard flashing LED, and if the overvoltage system activates the charge current will drop to zero.

Installation – Diagram

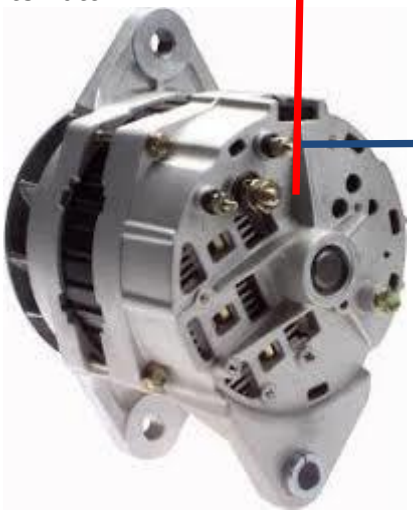
Earth lines left out for clarity of the drawing

Field & Ignition Fuse 5 amp
Battery Fuse 1 amp

House battery bank

Ignition switch

Alternator



Connect **NO** bigger than 18 gauge (0.75mm) (7.5amp) tinned wires to the connector block.

Installation tips

Make sure your pulley ratios are correct for your cruising rpm, i.e., the alternator needs to be turning at least 3000 rpm, and preferably 5000 rpm and up to 8000 rpm for a decent charge to be outputting from your alternator.

Ensure your earth leads from the engine block to the alternator and starter are not used via the block. If there is any high resistance the earth trace will find itself tracking through your engine bearings and could cause arcing. Get peace of mind and run separate earth leads.

Try to use the same type of batteries i.e., Lead-acid /Gel / AGM. Don't mix them up.

Your installation should have two battery banks, one for starting and one for house loads.

Charge batteries in parallel, using a voltage-sensitive relay.

Make sure your engine has enough "belt" to drive the alternator you select.

Do not leave batteries discharged for extended periods.

Plan your battery capacity to ensure your house batteries are run no less than 50% of capacity.

Provide a means to cross-connect battery banks for emergency starting.

Protect circuits with fuses or circuit breakers.

Voltage drop is the enemy, look to find the offending connections and fix them.

Connecting batteries in series, the amp-hour capacity remains the same as a single battery however the voltage is doubled.

Connecting batteries in parallel, the amp-hour capacity is doubled and the voltage remains the same as a single battery.

An alternator has a huge fan that draws air from the back to the front of the alternator for cooling; imagine if this air has salt-laden air in it, this will cause corrosion in non-marinized alternators. Consider getting the internals painted in good quality paint to get a longer life out of your alternator.

Automotive 'in line' ammeters are a huge voltage drop in your charging system. If your system charges at a low current charge and quickly drops down to 10 amps it is most probably the 'in line' ammeter at fault. The best option is a 'shunt' type ammeter.

NEVER turn OFF the battery switch with the engine running, it can blow up the alternator and or the smart regulator.

Set up

It is suggested that you start this process with fully charged batteries. This will provide a stable platform for setting the ZM5 'set voltage'.

The charge voltage is factory set to (29.2v) 14.7 volts Absorption and (27.8v) 13.8 volts Float and the overvoltage is set to (30.5v) 15.5 volts. All set with a 5 -10 amp load You will need to fine tune the adjustments to take care of voltage drops in your own installation

If you are unsure if your alternator is configured correctly do the following test: Remove the field wire from ZM5 N and with the engine idling, briefly (2-4 seconds) hold the alternator field wire to earth. Field to positive for ZM5 P. Note: you will get a spark. You will hear the engine load up and the output voltage should quickly rise, this indicates the alternator is configured correctly. Connect a suitable digital voltmeter to the battery that you have the BATT connection on. Start the engine, monitor the battery voltage, and if required adjust.

The Green LED should illuminate to indicate the float voltage setting; this should be approximately in the range of 100-120 minutes of operation.

If you wish to adjust the ratio between Absorption and Float refer to section unit CHANGING RATIO.

Final settings to voltage should be made once the engine is at normal cruise RPM.

Note: voltage setting should be done by turning the adjusting screw clockwise one turn = 0.12volt
This should be done **ONLY** when the Yellow Absorption LED is on.

Note: all screw adjustments are Clockwise to increase, Counter clockwise to decrease.

Suggested set voltages

12 VOLT UNITS

Suggested Set Voltages	From	To
Lead Acid and AGM (Absorption Setting)	14.6 V	14.9 V
Lead Acid and AGM (Float Voltage)	13.8 V	14.0 V
Gel Cell (Absorption Setting)	13.9 V	14.4 V
Gel Cell (Float Voltage)	13.1V	13.8 V
LifeP04 (Absorption Setting)	14.0 V	14.3 V
LifeP04 (Float Voltage)	13.5 V	13.7 V

24 VOLT UNITS

Suggested Set Voltages	From	To
Lead Acid and AGM (Absorption Setting)	28.4 V	29.6 V
Lead Acid and AGM (Float Voltage)	27.2 V	28.4 V
Gel Cell (Absorption Setting)	27.6 V	28.4 V
Gel Cell (Float Voltage)	26.4 V	27.2 V
LifeP04 (Absorption Setting)	28.0 V	28.6 V
LifeP04 (Float Voltage)	27.0 V	27.4 V

Remember to set the voltage at your normal cruise rpm if possible and only adjust after the battery level has stabilised.

If you have a lead-acid battery with vented caps then you can set the voltage to the upper limit. If the battery is 'maintenance free' sealed type then you will need to set the voltage to the lower end of the scale.

Over the following weeks of operation monitor the water levels in your battery, you may find that due to gassing you will use slightly more water, this is quite normal. This is a far better situation than not using any water at all.

Once you have this set, there should not be any further adjustments required.

The above is only a guide, check with your battery manufacturer.

Changing ratio

The unit has been factory set to provide a ratio of 0.7v between the Absorption and Float rates. Some AGM batteries require a 1.0v ratio. To change this ratio, proceed as follows;

Note: Please read carefully before proceeding, if you get this wrong, you will have to send the unit back for factory adjustment.

1/ Note: all screw adjustments are as follows, clockwise to increase, counter clockwise to decrease. (Later models have screw horizontal for ratio and overvoltage potentiometers)

2/ with the engine running at normal cruise rpm and normal load applied and **ONLY** when the **Green** Float LED is **On**. Adjust the VOLT ADJ potentiometer to the desired **lower** voltage, let's say 13.7v, stabilise and ensure voltage steady on the desired figure, do not re-adjust this pot until finished items 3 and 4.

3/ Momentarily disconnect the unit from the power source. ZM5P disconnect Ignition terminal – ZM5N disconnect Negative terminal, once tripped, the **Yellow** Absorption LED will be On.

4/ You then adjust the RATIO potentiometer to the desired **upper** voltage, say 14.7v, stabilise for 5 minutes and ensure voltage steady on the desired figure.

Changing Overvoltage sense.

The factory default setting is 15.5 volts, 24-volt versions (31 volts), you might find after first installing the unit and it runs for a period of a few minutes and then the overvoltage sense may activate. This is normal and we attribute this to wiring fluctuations within your installation, adjust in $^{1/8}$ of a turn after each reset until the alarm does not sound.

Each turn on the adjustment potentiometer is:
¼ of a turn = 0.4 volts
½ turn = 0.7 volts
1 turn IN = 1.25 volts.

Adjusting threshold

1/ Adjust the "OVolt" adjusting screw in (clockwise) 2 turns to take it well out of range.
2/ Set "Volt Adj" voltage at 14.5 volts (29 volts)
3/ Adjust over-voltage screw out slowly (counter clockwise) until the warning buzzer activates.
4/ Adjust over-voltage screw in 1 turn
5/ Reset by removing the jumper or reset ignition.

We have had users report that the overvoltage will activate during start-up, this generally occurs due to voltage slumping to below 10.6v, if you cannot find a cause remove the jumper and try again, if it resolves the issue the overvoltage sensing will remain inactive with the jumper removed.

At times there are voltage spikes within your electrical system typically these are inductive loads (motors of a high current draw). The ZM5 is detecting these spikes and isolating the system, reset the jumper, and monitor what is creating the spike. If it cannot be prevented you may need to adjust the setting threshold up slightly to reduce the annoying warning.

FAQ – Frequently Asked Questions

Q What wiring changes are required on my existing installation?

A As well as running a wire to your alternator field terminal, you will need an ignition source to the ZM5 and a battery positive and earth.

Q Will this unit work through a VSR (Voltage Sensitive relay)?

A Yes. A good way to allow dual battery charging.

Q Will this unit work through a diode splitter?

A Yes. The ZM5 can compensate for the typical voltage drop over a diode bank, providing that the battery sense wire is on the battery side of the diode bank.

Q Can I fit a ZM5 to an outboard motor?

A No. For the ZM5 to work it must have a field control, an outboard motor does not have this function.

Q Can I fit a ZM5 to a solar panel or wind turbine?

A No. For the ZM5 to work it must have field control.

Q Can the ZM5 run two alternators?

A Yes, check our website for wiring configuration.

Q What changes are required to my alternator?

A This does depend on your alternator type; some are easy to convert others are a bit more difficult. Check our website for wiring configuration.

Q Can I modify my alternator?

A Yes. It is a matter of running a field wire to the appropriate side of the brush block.
The ZM5 N controls the earth side of the brushes.
The ZM5 P controls the positive side of the brushes.

Q What is the difference between N and P switching

A Certain manufacturers elect to switch the positive brush whilst the majority of others switch the negative brush, as a user you do not know the difference in an operational sense.

Q Can you provide the modification required for my alternator?

A Yes, call with the details first.

Q Can you refurbish my alternator and convert it to an external regulator?

A Yes, we do this regularly for clients.

FAQ – continued

Q I have been told that a smart regulator is hard on my alternator?

A The old adage, the harder you work something the faster it is going to wear out. Good regular maintenance must be adjusted accordingly. There are some less suitable alternators out there. Call and discuss your brand.

Q Why does my voltage vary with lower engine rpm?

A It is an indication of the alternator output being too low for that given rpm, so your battery capacity and or status is too low for the unit to be able to achieve the desired set voltage.

Q Can I connect the V+ brush directly to the B+ terminal?

A Only on a ZM5 N model. This will work fine and will not drain your battery as the ZM5 field circuit is disconnected during ignition-off situations.

Q What is the system for switching over from Absorption to Float?

A It is a combination of time and a sensing circuit detecting the state of charge of your batteries. The Green LED should illuminate to indicate the float voltage setting; this should be approximately in the range of 100 - 120 minutes of operation.

Q Sometimes my Overvoltage buzzer sounds although my voltage setting is correct.

A At times there are voltage spikes within your electrical system typically these are inductive loads (motors of a high current draw). The ZM5 is detecting these spikes and isolating the system, reset the jumper, and monitor what is creating the spike. If it cannot be prevented you may need to adjust the setting threshold up slightly to reduce the annoying warning.

Q Why does my overvoltage buzzer and LED sound at times when I do not have an overvoltage situation?

A Could well be an over-temperature situation that trips the same overvoltage buzzer. The system will activate with component internal failure or fan failure.

Q Can I connect the ZM5 Ignition terminal to the alternator D+ Ignition light connection?

A No, as the alternator will drop out the feed once the alternator is excited and the ZM5 ignition feed will be lost.

On initial turn on the field current will be in the order of 3 amps, if your ignition supply voltage is too low this can cause the overvoltage LED to flash

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Fault Finding

Write down the circumstances leading to the discovery that a problem exists. Make it as clear as possible. If you're not charging, and you have just installed a new alternator, suspecting the regulator is faulty may not be the best decision. Wiring errors or compatibility issues between the alternator and regulator are prime suspects. We are happy to work through any charging issues you have, but please do the basic fault finding first. The majority of faults reported are wiring installation issues.

No Alternator Output

Check to see if there is a voltage supply to the IGN terminal on ZM5, Absorption LED should be ON.

Is the ignition light connected and working correctly, i.e.: is the alternator 'excited'? Check fuses.

Remove the field wire from ZM5 N and with the engine idling, briefly (2-4 seconds) hold the alternator field wire to earth. Note: you will get a spark. You will hear the engine load up and the output voltage should quickly go towards 16v+.

Remove the field wire from ZM5 P and with the engine idling, briefly (2-4 seconds) hold the alternator field wire to positive. Note: you will get a spark. You will hear the engine load up and the output voltage should quickly go towards 16v+.

This would indicate that the alternator is fine and the ZM5 is at fault.

Another way of checking the field output is to put a small wattage bulb (incandescent) between FIELD and BATT on a ZM5 or between FIELD and EARTH for a ZM5 P and again adjust the pot. You should see light come on. However, the battery voltage must be above 13.6 volts for this test to work.

Overvoltage Flashing

There are several scenarios that this LED could activate:

1/ If this LED flashes at "ignition on" it indicates an internal microprocessor fault, unit will not function, return to supplier, or a voltage low situation on the IGN feed, check the voltage with the unit on, must be above 10.6v or try getting another source of voltage from a battery of known voltage to check if the problem persists.

2/ If the LED and alarm sounds during operation, either a transient spike occurred or the unit is overvoltage, try resetting jumper bridge, and if the fault persists try turning down the voltage adjuster at least 6 turns and try again.

Product Liability

In no event shall we be held liable for any direct, indirect, punitive, incidental, special consequential damages, to property or life whatsoever, arising out of installation or misuse of our products. Please ensure installation is as per our installation instructions.

Warranty Details

This unit is covered by a 24-month warranty on a return-to-base basis.

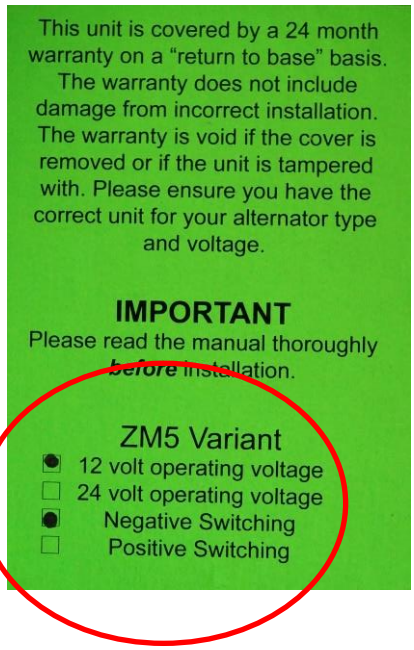
We will repair or replace free of charge; we cannot offer an exchange service.

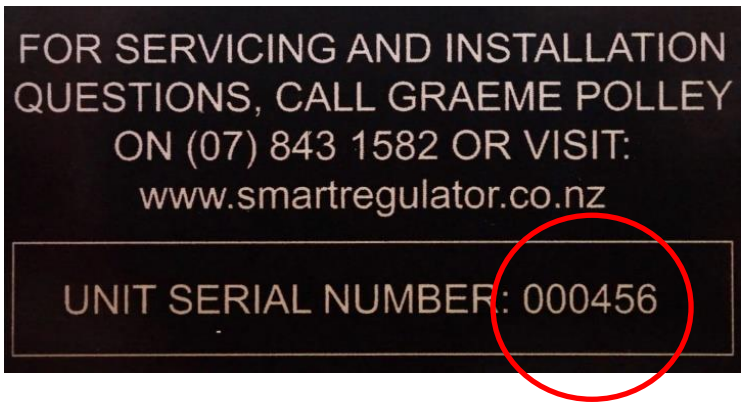
Freight charges to return units are not covered by warranty.

The warranty does not include damage from incorrect installation.

The warranty is void if the cover is removed or if the unit is tampered with.

A full refund will be provided to any goods returned to our facility, in their original packaging, and within 30 days and if the goods have not been used. If goods have been used or installed and powered up then a recertification fee of up to 15%, will apply. This is to ensure no damage has occurred during installation and power up. Shipping expenses, in both directions, are not refundable.





Phone Assistance

We are happy to provide telephone support, however, we are not mind readers and you will get asked "did you follow the fault-finding section" before you ring our office!

Also do read the FAQ as we try to include topics whenever people experience problems.

When you do make contact please provide as much information about your installation so that we can best assist with fault finding.

I also need to know whether you have an N or P ZM5 also, simple clue:

red circuit board = "P version"

green circuit board = "N version"

You can save yourself (and I) a lot of grief if you have done this, before ringing, and remember everyone blames the "little black box" first before looking at other components in the loop!!

As the old saying goes RTFM

Contact Details

For any questions or warranty matters contact:

Graeme Polley

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